Theoretical and Numerical Studies of Variability and Predictability in an Unsteady Ocean

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LONG-TERM GOALS

Our long-term goals are to understand the nature of variability within the ocean, in particular that due to the motion of mesoscale eddies and their interaction with and dependence on the general circulation.

OBJECTIVES

Our particular objectives are to understand the nature and predictability of mesoscale eddies in the ocean. This includes the mechanisms of their equilibration, their structure and energetics, and their dependence on the large-scale parameters set by the general circulation.

APPROACH

Our approach is to use a hierarchy of numerical and analytic models of the ocean circulation, of varying complexity. At the simplest level are linear quasi-geostrophic models of baroclinic instability. At the next level are nonlinear, eddy resolving quasi-geostrophic models in idealized domains. Finally, we employ eddy resolving primitive equation models in fairly realistic configuration and domain.

WORK COMPLETED

We have completed a sequence of integrations using a quasigeostrophic model to explore the equilibration properties of mesoscale eddies, with oceanically realistic stratification. In collaboration with GFDL scientists we have configured two primitive equation numerical models to perform eddy resolving integrations of the Southern Ocean, and some preliminary experiments have been performed.

RESULTS

Considerable progress has been made in understanding the mechanisms that determine the scale and equilibration of mesoscale eddies in the ocean. Application of the theory of geostrophic turbulence has led to analytic predictions of the scale and magnitude of such eddies. It has been shown that the effects of non-uniform stratification (i.e., the presence of a thermocline) leads to a changing of the energetic pathways of mesoscale eddies, with the preferential concentration of baroclinic energy at the scale of the first deformation radius, in some contrast to classical theory in which the energy cascades to the gravest horizontal and vertical scales.

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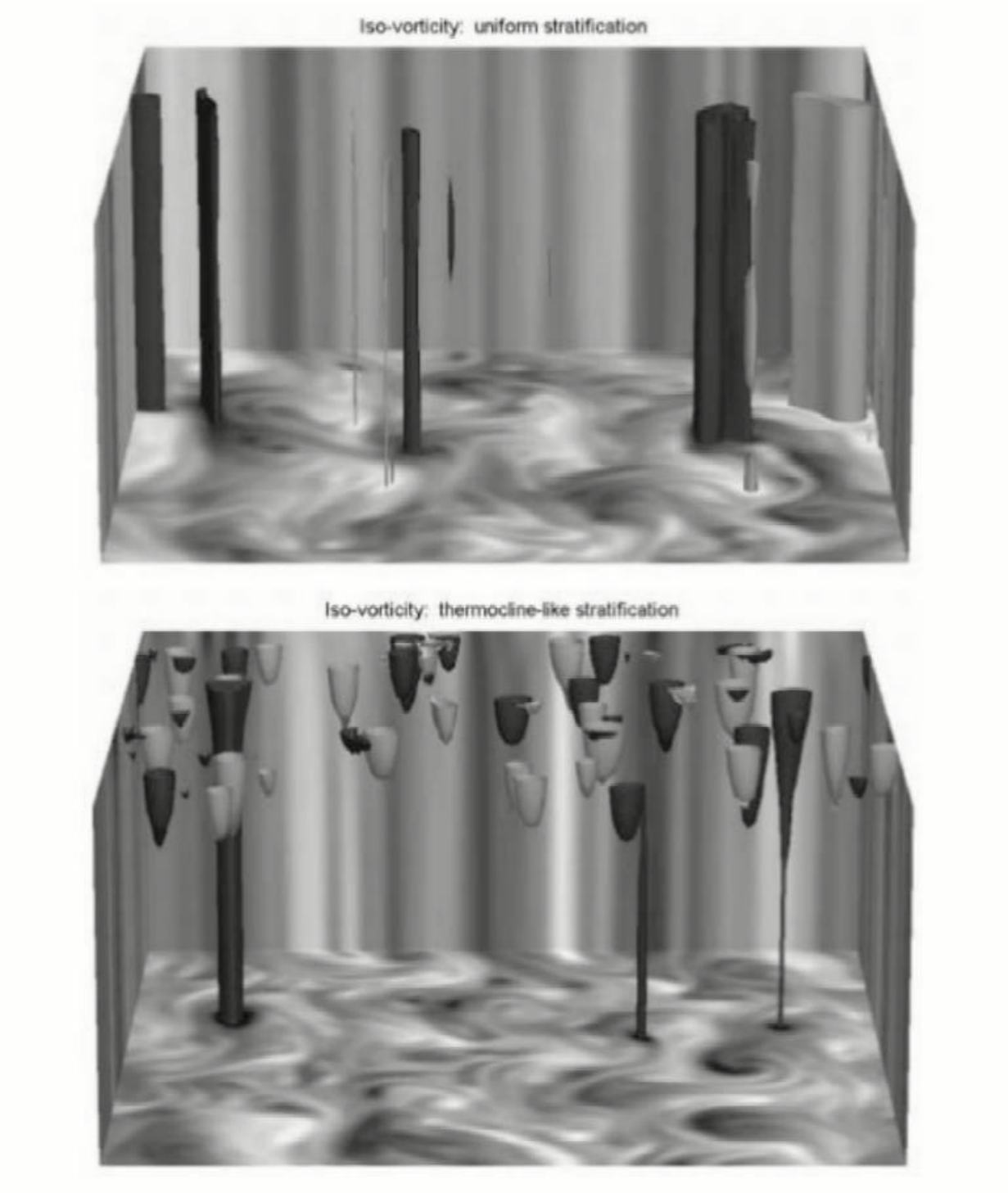

Different vorticity structures produced by mesoscale eddies in the presence of a uniform stratification (top) and a realistic stratification (bottom). Note the surface trapping in the lower case. From Smith and Vallis (2000, J. Phys. Oceanogr., in press)

IMPACT/APPLICATIONS

The impact of this lies in understanding the nature of mesoscale energetics in the ocean, and its dependence on the large scale parameters of the oceanic general circulation. Results from the more realistic simulations will indicate the predictability of the ocean on the mesoscale and deformation scales.

TRANSITIONS

Our results have not yet appeared in print. But nevertheless they are being used to interpret the results of altimeter measurements and primitive equation numerical models.

RELATED PROJECTS

A related GFDL/NOAA funded project on modeling eddies provides an invaluable insight into eddies in the Southern Ocean, as well as the resources for the extensive primitive equation calculations. In particular, GFDL is providing all the computer time for the experiments we are doing here, at no cost to ONR. We continue to collaborate closely with GFDL scientists.

PUBLICATIONS

Smith, K. S. and G. K. Vallis. Scales and equilibration of mid-ocean eddies: Freely decaying flow. *J. Phys. Oceanogr.* (in press).

Schonbek, M. and Vallis, G. K. Energy Decay of Solutions to the Boussinesq , Primitive and Planetary Geostrophic Equations. *J. Math. Analysis & Applics*. 234, 457-481.

Vallis, G. K. Large-scale circulation and production of stratification: effects of wind, geometry and diffusion. *J. Phys. Oceanogr.,* 30, 933--954.